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NINETEEN ARTIFICIAL BISPECIFIC *LOBELIA* HYBRIDS[1]

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Introduction

Bowden (1961) reported the general results of an interspecific hybridization program that involved the 21 species of *Lobelia* L. section Lobelia. In the same paper, a cytotaxonomic treatment was given for *L.* × *rogersii* Bowden which is the name for natural and artificial hybrids of the parentage, *L. brevifolia* Nutt. × *L. puberula* Mx.

The present paper is a cytotaxonomic treatment of 19 of the 33 hybrids listed in Table II of Bowden (1961). It is planned to treat the nothomorphs of *L.* × *speciosa* Sweet (*L. siphilitica* L. × *L. cardinalis* L.) and the 12 complex tetraploid hybrids listed by Bowden (1961) in later papers.

The materials of the *Lobelia* species used as seed or pollen parents of these artificial hybrids were described by Bowden (1959, 1960a and 1960b). The methods used during the *Lobelia* hybridization program were described by Bowden (1961).

Results

The present paper is a treatment of 13 artificial bispecific diploid *Lobelia* hybrids, six artificial bispecific tetraploid hybrids and one artificial bispecific hexaploid hybrid. Both diploid and tetraploid hybrids of the parentage, *L. siphilitica* L. var. *siphilitica* × *L. puberula* Mx. f. *puberula*, were grown and they are treated separately.

In the text, the formulae of parentages of the 19 bispecific hybrids are stated. Binary names are not assigned because specimens of these 19 hybrids are all artificial hybrids and numerous binary names would be cumbersome. In the case of *L.* × *rogersii* (*L. brevifolia* × *L. puberula*) and *L.* × *speciosa* (*L. siphilitica* × *L. cardinalis*), binary names as well as formulae of parentages were used by Bowden (1961) since both natural and artificial hybrid specimens were known. Also, *L.* × *speciosa* has been frequently grown in gardens over a long period of time. In the formulae of parentages of the artificial hybrids, the seed parent (♀) is always given first (before the ×) and the pollen parent (♂) is given second.

Herbarium specimens of representative artificial hybrid plants were prepared and voucher specimens are cited under each hybrid combination. The main set of specimens of the artificial hybrids is deposited in the Phanerogamic Herbarium of the Plant Research Institute (DAO). Some duplicate specimens of some hybrid populations have also been deposited at various herbaria (NY, MICH, MO, US, GH, BH, K and W) and a smaller number of duplicates were placed in several other herbaria. The symbols for herbaria are those of Lanjouw and Stafleu (1959).

The cytotaxonomic data for these artificial hybrids are recorded under the following headings: (1) parentage; (2) morphology of the hybrids: (3) somatic ($2n$) chromosome number, and meiotic chromosome behavior, usually

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MI or diakinesis, and *n* chromosome number; (4) pollen characteristics; (5) sterility or fertility of the hybrids when tested by self-pollination: and (6) voucher specimens. Abbreviations used in the text are explained in previous papers by Bowden (1959, 1960a, 1960b, 1961).

Thirteen Artificial Bispecific Diploid Hybrids

1a. LOBELIA PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. PUBERULA × L. GEORGIANA McVaugh

Morphology

Stem rather delicate to slightly coarse, 40-78 cm high, short-hirsute toward the base, the pubescence less dense below the raceme; cauline leaves usually broadly lanceolate, up to 3.8 cm wide and up to 6.5-10 cm long, the margins usually subentire; flower including hypanthium, (16)-21-25-(28) mm long; pedicels glabrous, nearly glabrous or puberulent toward the bases, hirsute, puberulent or nearly glabrous below the hypanthia; calyx-lobes entire or with few or rather numerous conspicuous glandular teeth; hypanthium hirsute, puberulent, nearly glabrous or glabrous; filament-tube (6.0)-7.0-8.5-(8.8) mm long; anther-tube usually blue-gray, (3.0)-3.5-3.8 mm long.

The mature F_1 hybrids (×-1069) were quite vigorous.

Chromosome Number and Behavior

In two F_1 hybrids, ×-1069-S2 and -S6, $2n = 14$ and in ×-1069-S5, $2n = 14 + 1$ sup. In ×-1069-S7, there were 7 II per cell in 10 PMC's; 6 II + 2 I per cell in 9 PMC's; and 5 II + 4 I in 1 PMC.

Pollen

In an F_1 hybrid, ×-1069-S7, there were 233 normal grains to 80 abnormal pollen grains. In a blue-gray anther-tube of ×-1069-S6, the pollen was 71 to 74% normal.

Sterility-fertility

Three different F_1 hybrids, ×-1069-S1, -S10 and -S6, were each self-pollinated and some seeds for F_2 populations were collected. The F_2 plants were weak and did not mature.

Voucher Specimens

×-1069: *L. puberula* f. *puberula*, 107-54-S1, six miles northeast of Williamston, North Carolina, × *L. georgiana*, 91-54, Elko, Virginia. ×-1069-S2, -S3, -S5, -S6, -S7, -S9, -S11 and -S12, greenhouse, Sept. 2 to 30, 1955 and July 27, 1956.

1b. LOBELIA PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. SIMULANS (Fern.) Bowden × L. GEORGIANA McVaugh; and reciprocal

Morphology

The F_1 hybrids are morphologically similar to those described under 1a. The cauline leaves are up to 4.6 cm wide and up to 13 cm long and the hypanthia are glabrous or slightly puberulent.

Only a few vigorous F_1 hybrids of two populations were grown to maturity.

Voucher Specimens

×-1170: *L. puberula* f. *simulans*, 6-6-B-S3, Buncombe Co., North Carolina, × *L. georgiana*, 91-54-S7, Elko, Virginia. ×-1170-S1, greenhouse, July 4, 1957.

×-1123: *L. georgiana*, 91-54-S11, Elko, Virginia, × *L. puberula* f. *simulans*, 6-6-B-S1, Buncombe Co., North Carolina. ×-1123-S1, greenhouse, Aug. 14, 1956.

1c. F_1 Hybrid (LOBELIA PUBERULA MX. F. PUBERULA × L. GEORGIANA McVaugh) × L. PUBERULA MX. F. PUBERULA; and reciprocal backcross

Morphology

Stem coarser than the F_1 hybrid (see 1a), taller, up to 123 cm high, the stem pubescence denser and more conspicuous; pedicels densely short-hirsute or hirsute, or puberulent or nearly glabrous toward the bases and sparsely pubescent or hirsute below the hypanthia; calyx-lobes entire with ciliate margins; hypanthium usually densely white-hirsute, rarely nearly glabrous; filament-tube 7.5-9.0-(9.5) mm long; anther-tube blue-gray, (3.3)-3.5-4.0 mm long.

Many vigorous backcross hybrids of two populations were grown to maturity.

Chromosome Number

In two backcross hybrids, ×-1213-S1 and -S5, $2n = 14$.

Pollen

In a blue-gray anther-tube of a backcross hybrid, ×-1213-S1, the pollen was about 97% normal.

Voucher Specimens

×-1229: (*L. puberula* f. *puberula* × *L. georgiana*), ×-1069-S4, × *L. puberula* f. *puberula*, 107-54-S2, six miles north-east of Williamston, North Carolina. ×-1229-S1, -S2, -S5, -S6, -S7, -S8 and -S9, greenhouse, July 27 to Aug. 20, 1956.

×-1213: *L. puberula* f. *puberula*, 107-54-S2, six miles north-east of Williamston, North Carolina, × (*L. puberula* f. *puberula* × *L. georgiana*), ×-1069-S7. ×-1213-S1, -S8, -S9, -S10, -S11, -S14 and -S16, greenhouse, July 27 to Aug. 8, 1956.

1d. F_1 Hybrid (LOBELIA PUBERULA MX. F. PUBERULA × L. GEORGIANA McVaugh) × L. GEORGIANA McVaugh; and reciprocal backcross

Morphology

Stem sometimes coarser than the F_1 hybrid (see 1a), sometimes taller, up to 141 cm high, short-hirsute toward the base, glabrous or nearly glabrous below the raceme; cauline leaves with subentire, crenulate or serrate margins; pedicels nearly glabrous to puberulent, or glabrous toward the bases and slightly puberulent or short-hirsute below the hypanthia; calyx-lobes with few to numerous conspicuous glandular teeth; hypanthium glabrous, slightly-pubescent or hirsute toward the base, or with numerous stunted hairs; filament-tube 7.0-8.5 mm long; anther-tube blue-gray or dark-coloured, 3.0-4.0-(4.3) mm long.

Many vigorous backcross hybrids of ×-1230 and a small number of a second backcross population, ×-1212, were grown to maturity.

Pollen

In a blue-gray anther-tube of a backcross hybrid, ×-1230-S5, the pollen was 87% normal.

Voucher Specimens

×-1230: (*L. puberula* f. *puberula* × *L. georgiana*), ×-1069-S4, × *L. georgiana*, 91-54-S16, Elko, Virginia. ×-1230-S1, -S2, -S4, -S5, -S7, -S9 and -S20, greenhouse, Aug. 8 to 28, 1956.

×-1212: *L. georgiana*, 91-54-S2, Elko, Virginia, × (*L. puberula* f. *puberula* × *L. georgiana*), ×-1069-S9. ×-1212-S1 and -S3, greenhouse, Aug. 8 and 28, 1956.

2a. LOBELIA SIPHILITICA L. var. SIPHILITICA × L. PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. PUBERULA
(see also No. 1 under tetraploid hybrids)

Morphology

Stem coarse, up to 75 cm high, sparsely short-hirsute to densely hirsute toward the base, densely or sparsely hirsute below the raceme; cauline leaves broadly lanceolate, up to 7.0 cm wide and up to 15.6 cm long, the margins subentire or crenulate; flower including hypanthium 20-26-(29) mm long; pedicels hirsute; flower-bracts small or large and leafy; calyx-lobes hirsute-ciliate, the margins usually entire or sometimes with a few or many glandular teeth, with small or conspicuous auricles; hypanthium densely or sparsely hirsute; filament-tube 9.0-11.5 mm long (measured in flowers with blue-gray anther-tubes); anther-tube blue-gray or pale-coloured, the blue-gray anther-tubes 3.5-4.7 mm long.

Numerous vigorous F_1 hybrids of eleven populations were grown to maturity.

Chromosome Number and Behavior

Three F_1 hybrids (×-452-S1, ×-453-S1 and X-464-S7) were examined and were diploid, $2n = 14$. At MI in ×-233-S3, there were 7 II + 1 sup. per cell in 14 PMC's; 6 II + 2 I + 1 sup. per cell in 8 PMC's; and 5 II + 4 I + 1 sup. per cell in 3 PMC's. At MI in ×-233-S1, there were 7 II per cell in 20 PMC's; 6 II + 2 I per cell in 4 PMC's; and 4 II + 6 I in 1 PMC. At MI in a second flower of ×-233-S1, there were 7 II per cell in 19 PMC's; 6 II + 2 I per cell in 6 PMC's; and 5 II + 4 I per cell in 2 PMC's. Diakinesis in ×-233-S2 showed 7 II per cell in 10 PMC's; 6 II + 2 I per cell in 6 PMC's; 5 II + 4 I per cell in 2 PMC's; and 4 II + 6 I per cell in 2 PMC's. Diakinesis in ×-233-S4 showed 7 II per cell in 20 PMC's and 6 II + 2 I per cell in 5 PMC's.

×-346 was a mixture of diploids and tetraploids (see hybrid No. 1 under tetraploid hybrids). In ×-346-S2, $2n = 14$; at early diakinesis, there were 7 II per cell in 21 PMC's; 6 II + 2 I per cell in 3 PMC's; and 4 II + 6 I in 1 PMC.

Pollen

In a blue-gray anther-tube of an F_1 hybrid, ×-233-S3, the pollen was 30 to 35% normal.

Sterility-fertility

×-233-S3, an F_1 hybrid, was self-pollinated; a few seeds were collected and four F_2 plants were grown. The specimen (×-361-S-S1) resembles the plant of ×-233-S3. ×-233-S1 was self-pollinated but no seeds were obtained.

Voucher Specimens of F_1 *Hybrids*

×-116: *L. siphilitica* var. *siphilitica*, 1-56, pollen-sterile, northern Virginia, × *L. puberula* f. *puberula*, 3-2, Charleston Co., South Carolina. ×-116-S1, -S2, -S3, -S6, -S8, -S10 and -S19, arboretum plots, July 16, 1948 to Sept. 6, 1949.

×-317: *L. siphilitica* var. *siphilitica*, 1-56, pollen-sterile, northern Virginia, × *L. puberula* f. *puberula*, 6-1-S20, Charleston Co., South Carolina. ×-317-S2, -S4, -S6 and -S9, arboretum plots, Aug. 9 to 17, 1949. ×-317-S2, greenhouse, May 19, 1949.

×-117: *L. siphilitica* var. *siphilitica*, 1-56, pollen-sterile, northern Virginia, × *L. puberula* f. *puberula*, 6-2, Greensboro, North Carolina. ×-117-S1, -S2, -S7, -S8, -S9, -S10 and -S11, arboretum plots, June 8, 1948 to Aug. 23, 1949.

×-233: *L. siphilitica* var. *siphilitica*, ×-112-S2, interstrain hybrid (1-56

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northern Virginia × 1-54, Turkey Point, Ontario), × *L. puberula* f. *puberula*, 6-2-S3, Greensboro, North Carolina. ×-233-S1, -S2, and -S3, greenhouse, May 7 to June 9, 1949.

×-302: *L. siphilitica* var. *siphilitica*, 1-56, pollen-sterile, northern Virginia, × *L. puberula* f. *puberula*, 6-2-S3, Greensboro, North Carolina. ×-302-S1, greenhouse, May 19, 1949.

×-316: *L. siphilitica* var. *siphilitica*, 1-56, pollen-sterile, northern Virginia, × *L. puberula* f. *puberula*, 6-2-S8, Greensboro, North Carolina. ×-316-S1, arboretum plots, Aug. 9, 1949.

×-346: *L. siphilitica* var. *siphilitica*, 1-50-S11, Knoxville, Tennessee, × *L. puberula* f. *puberula*, 6-1-S3, Charleston Co., South Carolina. No specimen of S2 (diploid) was preserved. See also tetraploid hybrid No. 1.

×-452: *L. siphilitica* var. *siphilitica*, 1-69-S1, Turkey Point, Norfolk Co., Ontario, × *L. puberula* f. *puberula*, 6-2-S54, Greensboro, North Carolina. ×-452-S2, -S18 and -S20, arboretum plots, Oct. 16, 1950 to Sept. 28, 1951.

×-464: *L. siphilitica* var. *siphilitica*, 1-65, Turkey Point, Norfolk Co., Ontario, × *L. puberula* f. *puberula*, 6-2-S53, Greensboro, North Carolina. ×-464-S2, -S4, -S5 and -S9, arboretum plots, July 28, 1950 to Sept. 26, 1950. ×-464-S4, greenhouse, May 26, 1950.

×-347: *L. siphilitica* var. *siphilitica*, 1-50-S11, Knoxville, Tennessee, × *L. puberula* f. *puberula*, 6-2-S3, Greensboro, North Carolina. Four hypanthia were harvested for the F_1 and a few F_1 hybrids were grown. No specimens of ×-347 were preserved.

×-453: *L. siphilitica* var. *siphilitica*, 1-47-S1, Tarrytown, New York, × *L. puberula* f. *puberula*, 6-5-S6, Chancellorsville, Virginia. Good seed for the F_1 was harvested and some F_1 hybrids were grown. No specimens of ×-453 were preserved.

Voucher Specimen of F_2 *Hybrid*

×-361-S: F_2 plants that resulted from the self-pollination of an F_1 hybrid, ×-233-S3. ×-361-S-S1, arboretum plots, Aug. 31, 1950.

2b. LOBELIA SIPHILITICA L. var. SIPHILITICA × L. PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. SIMULANS (Fern.) Bowden

Morphology

The F_1 hybrids are morphologically similar to those described under 2a. The F_1 hybrids of ×-1250 are vigorous specimens.

Pollen

In a blue-gray anther-tube of an F_1 hybrid, ×-1250-S4, the pollen was ~~11~~ to 50% normal.

Sterility-fertility

×-1250-S3, an F_1 hybrid, was self-pollinated. Three fair-sized hypanthia were harvested and nine F_2 plants were grown.

Voucher Specimens

×-1250: *L. siphilitica* var. *siphilitica*, 1-88-S1, Lake Geneva, Wisconsin, × *L. puberula* f. *simulans*, 6-6-B-S4, Buncombe Co., North Carolina. ×-1250-S1 and -S4, greenhouse, July 13 and July 31, 1956.

2c. LOBELIA SIPHILITICA L. var. SIPHILITICA × L. PUBERULA Mx. subsp PUBERULA var. MINEOLANA Wimmer

Morphology

The F_1 hybrids are morphologically similar to those described under 2a.

The flower-bracts are large, the calyx-lobes are entire or have a few small glandular teeth, and the anther-tubes are pale-coloured. The three specimens of ×-1392 are vigorous hybrids.

Voucher Specimens

×-1392: *L. siphilitica* var. *siphilitica*, 1-92, Watkins Glen, New York, × *L. puberula* var. *mineolana*, 6-20-S2, Union Parish, Louisiana. ×-1392-S1, -S4 and -S6, greenhouse, May 8 to 13, 1957.

2d. LOBELIA SIPHILITICA L. VAR. SIPHILITICA × L. PUBERULA Mx. subsp. PUBERULA VAR. OBTUSIFOLIA (A.DC.) Fern.

Morphology

The F_1 hybrids are morphologically similar to those described under 2a. The stems are hirsute near the bases and glabrous or nearly glabrous below the racemes. The pedicels are short-hirsute. The calyx-lobes are glabrous or nearly glabrous and the margins are entire or have few or rather numerous glandular teeth. The hypanthia are glabrous, nearly glabrous, or sparsely hirsute. The anther-tubes are pale-coloured and underdeveloped. The three specimens of ×-1358 are vigorous hybrids.

Voucher Specimens

×-1358: *L. siphilitica* var. *siphilitica*, 1-92, Watkins Glen, New York, × *L. puberula* var. *obtusifolia*, 6-23-S3, Allen Parish, Louisiana. ×-1358-S1, -S2 and -S3, greenhouse, May 8 to 21, 1957.

2e. LOBELIA SIPHILITICA L. var. SIPHILITICA × L. PUBERULA Mx. subsp. PAUCIFLORA (Bush) Bowden

Morphology

Stem coarse, up to 65 cm high, hirsute; cauline leaves up to 4.0 cm wide and up to 11 cm long; flower including hypanthium (26)-30-31 mm long, the lower corolla-lobes often very large; pedicels densely hirsute to long-hirsute; calyx-lobes broad toward the bases, sparsely hirsute on the bodies, densely hirsute to ciliate-hirsute on the margins, with conspicuous auricles; hypanthium densely long-hirsute; filament-tube 11-15 mm long; anther-tube blue-gray or pale-coloured, the blue-gray anther-tubes 4.3-4.5 mm long.

The specimens of this hybrid are morphologically different from those described under 2a and show a strong influence of the pollen parent, *L. puberula* subsp. *pauciflora*. The F_1 hybrids of ×-827 and ×-833 are vigorous.

Chromosome Number and Behavior

At diakinesis in an F_1 hybrid, ×-827-S1, there were 7 II per cell in 16 PMC's and 6 II + 2 I per cell in 9 PMC's. At diakinesis in ×-833-S13, there were 7 II per cell in 21 PMC's; 6 II + 2 I per cell in 3 PMC's; and 5 II + 4 I in 1 PMC. At diakinesis in another flower of ×-833-S13, there were 7 II per cell in 6 PMC's; 6 II + 2 I per cell in 12 PMC's; 5 II + 4 I per cell in 5 PMC's; and 4 II + 6 I per cell in 2 PMC's.

Pollen

In a blue-gray anther-tube of an F_1 hybrid, ×-833-S8, the pollen was 14 to 20% normal. The normal-appearing pollen grains may not have been functional. The abnormal grains were mostly small, thin-walled and had poorly-developed contents. A few abnormal grains were as large as the normal grains but had dense contents.

Voucher Specimens

×-827: *L. siphilitica* var. *siphilitica*, ×-419-S5, interstrain hybrid, × *L. puberula* subsp. *pauciflora*, 6-11-S4, Freestone Co., Texas. ×-827-S11 and -S14, arboretum plots, Sept. 1952.

×-833: *L. siphilitica* var. *siphilitica*, 1-84-S6, Porter Co., Indiana, × *L. puberula* subsp. *pauciflora*, 6-11-S8, Freestone Co., Texas. ×-833-S8, -S10 and -S13, arboretum plots, Sept. 1952.

2f. LOBELIA SIPHILITICA L. var. LUDOVICIANA A.DC. × L. PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. PUBERULA

Morphology

Specimens of this hybrid are similar to those described under 2a but differ as follows: stem hirsute; cauline leaves lanceolate, up to 3.0-(3.5) cm wide and up to 10 cm long; calyx-lobes with few or numerous conspicuous glandular teeth (the teeth often hirsute) on the hirsute-ciliate margins, or the margins entire, with conspicuous auricles; hypanthium hirsute; anther-tube blue-gray.

Five vigorous F_1 hybrids were grown to maturity.

Chromosome Number and Behavior

In an F_1 hybrid, ×-461-S1, $2n = 14$. At MI in ×-461-S4, there were 7 II per cell in 18 PMC's; 6 II + 2 I per cell in 5 PMC's; and 5 II + 4 I per cell in 2 PMC's.

Pollen

In ×-461-S4, there were 204 normal pollen grains to 189 abnormal grains.

Sterility-fertility

×-461-S4 was self-pollinated but no seeds were obtained.

Voucher Specimens

×-461: *L. siphilitica* var. *ludoviciana*, 1-76-1A-S5, three miles west of Brookville, Kansas, × *L. puberula* f. *puberula*, 6-5-S6, Spotsylvania Co., Virginia. ×-461-S1 (one sheet) and -S4 (four sheets), arboretum plots, Sept. 28, 1950 to Aug. 22, 1951.

2g. (LOBELIA SIPHILITICA L. var. SIPHILITICA × L. SIPHILITICA L. var. LUDOVICIANA A.DC.) × L. PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. SIMULANS (Fern.) Bowden

Morphology

The specimen of ×-688 is morphologically similar to those described under 2a but differs as follows: flower including hypanthium, smaller, 14-16 mm long; hypanthium hirsute; filament-tube about 5 mm long; anther-tube poorly developed, blue-gray or pale-coloured, about 2.2 mm long.

Only one vigorous F_1 hybrid of ×-688 was grown.

Voucher Specimen

×-688: (*L. siphilitica* var. *siphilitica*, 1-47-S7, Tarrytown, New York, × *L. siphilitica* var. *ludoviciana*, 1-76-1A-S5, three miles west of Brookville, Kansas), ×-536-S14, × *L. puberula* f. *simulans*, 6-6-S38, Buncombe Co., North Carolina. ×-688-S1, arboretum plots, Aug. 1, 1951.

2h. LOBELIA SIPHILITICA L. var. LUDOVICIANA A.DC. × L. PUBERULA Mx. subsp. PAUCIFLORA (Bush) Bowden

Morphology

The hybrids are morphologically similar to those described under hybrid No. 2e but differ as follows: cauline leaves lanceolate or oblong, up to 3.2 cm

wide; flower including hypanthium 20-24 mm long in ×-854-S2 and -S4, and 30-31 mm long in ×-854-S5, the lower corolla-lobes smaller than in hybrid No. 2e; pedicels densely long-hirsute; filament-tube 11-13 mm long.

Many F_1 hybrids of ×-854 were grown and the three specimens are vigorous.

Chromosome Behavior

At MI in a F_1 hybrid, ×-854-S1, there were 7 II per cell in 11 PMC's and 6 II + 2 I per cell in 4 PMC's.

Pollen

In a blue-gray anther-tube of ×-854-S5, the pollen was 4 to 8% normal. The normal-appearing grains may not have been functional. The abnormal grains were small, thin-walled and had poorly-developed contents.

Voucher Specimens

×-854: *L. siphilitica* var. *ludoviciana*, 1-76-1951-S1, three miles west of Brookville, Kansas, × *L. puberula* subsp. *pauciflora*, 6-11-S7, Freestone Co., Texas. ×-854-S2, -S4 and -S5, arboretum plots, Aug. 27 to Sept. 12, 1952.

3a. LOBELIA SIPHILITICA L. var. SIPHILITICA × L. GEORGIANA McVaugh; and reciprocal

Morphology

Stem coarse, up to more than 90 cm high, short-hirsute near or toward the base, glabrous, nearly glabrous or short-hirsute toward the raceme; cauline leaves mostly broadly lanceolate, large, up to 4-(4.6) cm wide and up to 12-15-(18) cm long, with entire or subentire margins with callose teeth; flower including hypanthium, 19-26-(31) mm long; pedicels, densely hirsute or short-hirsute, or puberulent, each pedicel with a pair of conspicuous bracteoles near or above the base, rarely near or above the middle of the pedicel; calyx-lobes entire or with well-spaced or rather numerous glandular teeth, the margins glabrous or hirsute, the auricles small or medium-sized; corolla-lobes, on the veins outside, hirsute, short-hirsute or rarely glabrous; hypanthium hirsute, or sometimes glabrous or nearly glabrous; filament-tube 9-11 mm long; anther-tube, often-pale-coloured, sometimes blue-gray or dark-coloured, (2.8)-3.6-4.5 mm long.

Numerous vigorous plants of four F_1 populations were grown.

Chromosome Number and Behavior

Six F_1 hybrids, ×-323-S1, -S2, -S3, -S4, -S5 and -S6, were diploid, $2n = 14$. At MI and diakinesis in ×-344-B-S1, an F_1 hybrid, there were 7 II per cell in 14 PMC's; 6 II + 2 I per cell in 12 PMC's; and 4 II + 6 I in 1 PMC. At MI in ×-344-S5, one flower had 7 II per cell in 23 PMC's and 6 II + 2 I per cell in 2 PMC's; and another flower had 7 II per cell in 22 PMC's and 6 II + 2 I per cell in 3 PMC's.

Pollen

The pollen of a pale-coloured anther-tube of ×-344-B-S1, an F_1 hybrid, was 100% abnormal. The pollen of a dark-coloured anther-tube of ×-1249-S1, another F_1 hybrid, was 37 to 47% normal.

Sterility-fertility

An F_1 hybrid, ×-1249-S2, was self-pollinated and three medium-sized hypanthia were harvested. Only one weak F_2 plant was grown.

Voucher Specimens

×-115: *L. siphilitica* var. *siphilitica*, 1-56, pollen-sterile, northern Virginia.

× *L. georgiana*, 4-2, Dorchester Co., South Carolina. ×-115-S7, -S12, -S26, -S27, -S28, -S34, -S36 and -S39, arboretum plots, 11 sheets, Sept. 1948 to Sept. 6, 1949. ×-115, greenhouse, May 7, 1948.

×-323: *L. siphilitica* var. *siphilitica*, 1-56, pollen-sterile, northern Virginia, × *L. georgiana*, 4-2, Dorchester Co., South Carolina. ×-323-S1, -S2, -S3 and -S6, arboretum plots, Aug. 9, 1949 to Sept.. 13, 1949. ×-323-S1, -S2 and -S3, greenhouse, May 7 to 14, 1949.

×-344: *L. siphilitica* var. *siphilitica*, 1-50-S11, Knoxville, Tennessee, × *L. georgiana*, 4-2, Dorchester Co., South Carolina. ×-344-S1, -S4 and -S5, greenhouse, five sheets, April, 1949 to Sept. 8, 1949. ×-344, arboretum plots, Aug. 17, 1949.

×-1249: *L. georgiana*, 91-54-S9, Elko, Virginia, × *L. siphilitica* var. *siphilitica*, 1-88-S1, Lake Geneva, Wisconsin. ×-1249-S1, greenhouse, Aug. 14, 1956.

3b. LOBELIA GEORGIANA McVaugh × L. SIPHILITICA L. var. LUDOVICIANA A.DC.

Morphology

The F_1 hybrids are morphologically similar to those described under 3a but differ as follows: stem up to more than 100 cm high, sparsely short-hirsute toward the base, glabrous above; cauline leaves up to 5 cm wide; hypanthium glabrous or with a few sparse hairs.

About ten F_1 hybrids were grown and the three preserved specimens were vigorous plants.

Chromosome Behavior

At diakinesis and MI in an F_1 hybrid, ×-1251-S1, there were 7 II per cell in 10 PMC's.

Pollen

The pollen of a blue-gray anther-tube of ×-1251-S1 was about 35% normal.

Sterility-fertility

An F_1 hybrid, ×-1251-S7, was self-pollinated. Two medium-sized hypanthia were harvested but contained no viable seeds.

Voucher Specimens

×-1251: *L. georgiana*, 91-54-S16, Elko, Virginia, × *L. siphilitica* var. *ludoviciana*, 2-3-S2, West Feliciana Parish, Louisiana. ×-1251-S1, -S8 and -S9, greenhouse, three specimens (five sheets), July 27 to Aug. 8, 1956.

4. LOBELIA SIPHILITICA L. var. SIPHILITICA × L. BREVIFOLIA Nutt.

Morphology

Stem about 113 cm high, rather coarse, with short hairs, usually the pubescence sparse, almost glabrous, or glabrous in part; cauline leaves up to 2.0-3.0 cm wide, and up to 7.0-10.5 cm long, the margins crenulate; flower including hypanthium, 18-29 mm long; corolla pale blue to hyacinth blue; each pedicel with a pair of bracteoles near the base; pedicel and hypanthium hirsute; calyx-lobes broad toward the bases, pubescent toward the apices, the margins with few or many small teeth; calyx-lobes with broad, leafy auricles at their bases, the auricles rounded, obtuse or acute, not fimbriate, nearly covering the hypanthium; filament-tube, 8.5-10.5 mm long; anther-tube usually blue-gray, sometimes pale-coloured, 3.3-4.0 mm long. These F_1 hybrids have a remarkable combination of the parental species characteristics.

About two dozen vigorous F_1 hybrids of ×-1221 were grown to maturity.

Chromosome Number and Behavior

In ×-1221-S1, an F_1 hybrid, $2n = 14 + 2$ sup. and in ×-1221-S2, $2n = 14 + 4$ sup. At MI in ×-1221-S1, there were 7 II + 2 sup. per cell in 3 PMC's; 6 II + 2 I + 2 sup. per cell in 3 PMC's; 5 II + 4 I + 2 sup. per cell in 4 PMC's; 4 II + 6 I + 2 sup. per cell in 6 PMC's; 3 II + 8 I + 2 sup. per cell in 7 PMC's; 2 II + 10 I + 2 sup. in 1 PMC; and 1 II + 12 I + 2 sup. in 1 PMC.

Pollen

In ×-1221-S1, an F_1 hybrid, pollen from a pale-colored anther-tube was 82% abnormal (smaller, shrivelled grains) and pollen from a blue-gray anther-tube was 66% abnormal. In ×-1221-S9, pollen from a blue-gray anther-tube was 48% abnormal. The larger grains, while appearing normal, may not have been functional.

Sterility-fertility

An F_1 hybrid, ×-1221-S12, was self-pollinated. Seven small hypanthia were harvested but contained no viable seeds.

Voucher Specimens

×-1221: *L. siphilitica* var. *siphilitica*, 1-88-S2, Lake Geneva, Wisconsin, × *L. brevifolia*, 7-2-S4, Mobile Co., Alabama. ×-1221-S1, -S3, -S8 and -S9, greenhouse, August 8 to 14, 1956.

5. LOBELIA GEORGIANA McVaugh × L. BREVIFOLIA Nutt.; and reciprocal

Morphology

Stem 34-38 cm high, rather slender, nearly glabrous; cauline leaves small, up to 7.0-13.0 mm wide and up to 26 mm long, the margins entire or subentire with small callose teeth; flower of ×-1265-S1, including hypanthium, 17 mm long and corolla-tube strigose outside with short corolla-lobes; pedicels puberulent in ×-1265-S1; calyx-lobes nearly entire or with rather prominent teeth, the auricles small, rounded; filament-tube of ×-1265-S1, 6.5-7.5 mm long. The two F_1 hybrids that were grown to maturity have a combination of the parental species characteristics.

Only a few plants of ×-1265 were grown and only one rather slender plant (S1) was grown to maturity. Many F_1 seedlings of ×-1231 were grown but most of them, including many albinos, died or were weak and formed only small rosettes. One rather weak plant (S1) that was grown to maturity had small flower buds which did not open normally and the corollas turned brown.

Pollen

The anthers of ×-1265-S1, an F_1 hybrid, were not connate (fused to form a tube as in the parental species) but each consisted of five separate segments which were pale blue and up to 2.0 mm long. No pollen could be seen. In ×-1231-S1, there were connate anther-tubes which were pale-coloured and 1.5-2.0 mm long. No pollen could be observed.

Voucher Specimens

×-1265: *L. georgiana*, 4-4-S1, near Rockingham, North Carolina, × *L. brevifolia*, 7-4-S5, Kiln, Hancock Co., Mississippi. ×-1265-S1, greenhouse, Sept. 25, 1956.

×-1231: *L. brevifolia*, 7-2-S3, Mobile Co., Alabama, × *L. georgiana*, 91-54-S15, Elko, Virginia. ×-1231-S1, greenhouse, March 5, 1957.

6. LOBELIA PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. PUBERULA × L. FEAYANA Gray

Morphology

Stem 6-19 cm high, delicate, densely short-hirsute (3 plants) or sparsely pubescent (one plant, S4); cauline leaves thin, yellowish-green, up to 1.0-1.6 cm wide and up to 3.0 cm long, the margins crenulate; flower (S1) including hypanthium, 7.3 mm long; pedicels short-hirsute in S1 and S4; calyx-lobes up to 6.0 mm long; filament-tube, 3.0 mm long; anther-tube pale-coloured, about 1.5 mm long.

Much seed for the F_1 was harvested from one medium-sized hypanthium. Many rather pale-green F_1 seedlings and a few albinos were grown. Some of the seedlings died and only four small plants were grown to maturity. One plant (S1) was larger, 19 cm high, and the other three were smaller 6-9.5 cm high. These four rather weak hybrids have a combination of the parental species characteristics but show a strong influence of the pollen parent, *L. feayana*.

Pollen

In ×-1394-S1, an F_1 hybrid, the anther-tubes were underdeveloped, pale-coloured and appeared to contain no pollen. The other three F_1 plants had unopened flower buds.

Voucher Specimens

×-1394: *L. puberula* f. *puberula*, 108-54-S3, southwest of Hertford, North Carolina, × *L. feayana*, 97-54, Volusia Co., Florida. ×-1394 (four small plants (S1 to S4) on one sheet), greenhouse, June 14, 1957.

7. LOBELIA FLACCIDIFOLIA Small × L. PUBERULA Mx. subsp. PUBERULA var. PUBERULA F. PUBERULA

Morphology

Stem weak, 1.7-3.5-15-0 cm high, delicate, densely short-hirsute, the hairs sparser for 6 cm below the lowest flower in S1; cauline leaves often purplish, small, up to 3.0-8.0 mm wide and up to 2.7 cm long, the margins subentire; flower (S1) including hypanthium, 18 mm long; pedicels short-hirsute; calyx-lobes with prominent teeth; filament-tube 5.5 mm long; anther-tube pale-coloured, 2.5 mm long.

Eight greenish seedlings and some albinos were grown but only three plants survived. One plant (S1) was grown to maturity and two other small weak plants survived but did not produce flowers. The three F_1 hybrids have a combination of the parental species characteristics but the hybrid plants are weakly developed.

Pollen

The anther-tube of ×-1191-S1, an F_1 hybrid, was pale-coloured and contained a relatively small amount of pollen. The pollen was 100% abnormal and consisted mostly of small grains with poorly-developed contents and thin walls.

Voucher Specimens

×-1191: *L. flaccidifolia*, 29-3-S1, east of Alapaha, Georgia, × *L. puberula* f. *puberula*, 107-54-S6, six miles northeast of Williamston, North Carolina. ×-1191-S1, -S2 and -S3, all on one sheet, greenhouse, Nov. 12, 1956.

8. LOBELIA FLACCIDIFOLIA Small × L. FEAYANA Gray

Morphology

Stem rather weak, 20 cm high, delicate, dark green, glabrous; cauline leaves greenish, white-pink-variegated, small, up to 9 mm wide and up to 2.3 cm long, the margins subentire; flower including hypanthium, 8-10 mm long; pedicels puberulent; calyx-lobes narrow, the margins entire, rarely toothed; filament-tube 4.0 mm long; anther-tube blue-gray, 1.5 mm long.

The F_1 seedlings were green, greenish-white-pink-variegated or albino. Nine seedlings survived the early growth stages. Only one rather weak hybrid specimen was preserved as herbarium material. This hybrid shows a strong influence of the pollen parent, *L. feayana*.

Pollen

The anther-tubes of ×-1299-S5, an F_1 hybrid, were blue-gray but contained a relatively small amount of pollen. The pollen consisted of 94% abnormal small grains with thin walls and poorly developed contents, 3% grains that appeared normal but may not have been functional, and 3% giant or large grains with abnormally deep-staining contents in iodine-potassium iodide solution.

Voucher Specimen

×-1299: *L. flaccidifolia*, 29-3-S4, Alapaha, Georgia, × *L. feayana*, 97-54, Volusia Co., Florida. ×-1299-S5, greenhouse, Nov. 25, 1956.

9. LOBELIA PUBERULA Mx. subsp. PUBERULA var. PUBERULA f. PUBERULA × L. APPENDICULATA A.DC.

Morphology

Stem coarse, 38-73 cm high, densely to sparsely short-hirsute, more pubescent toward the base; cauline leaves large, up to 1.3-4.0 cm wide and up to 4.0-10.0 cm long, sessile or subsessile, narrowed or rather broad at the base; flower including hypanthium, 12-16 mm long; pedicels puberulent; calyx-lobes, greenish and often pale toward the apices, or green-white variegated (×-1450-S1); calyx-lobes strongly glandular-ciliate (glandular teeth and short hairs) and auricles small, bearing short hairs; hypanthium short-hirsute; filament-tube 3.3-4.8 mm long; anther-tube, pale-coloured, underdeveloped in all specimens, 2.0-2.5 mm long.

Three different F_1 populations were grown from crosses that involved the same parental plants. About 39 F_1 seedlings were obtained and four large, quite vigorous F_1 plants were grown to maturity. These F_1 hybrids have a remarkable combination of the parental species characteristics. The two parents, *L. puberula* and *L. appendiculata*, are distantly related and the vigour of the four plants that were grown to maturity is somewhat surprising.

Pollen

The four F_1 hybrid specimens have many flowers but all of the anther-tubes are pale-coloured and underdeveloped. The pollen was not abundant in any of the anther-tubes and consisted of 100% small abnormal grains with thin walls and poorly-developed contents. The pollen of ×-1398-S1 was examined in iodine-potassium iodide solution. The anther-tubes and pollen of the three other hybrid specimens appeared to be similar to ×-1398-S1, as observed under the binocular dissecting microscope.

Voucher Specimens

×-1398: *L. puberula* f. *puberula*, 108-54-S3, southwest of Hertford, North

Carolina, × *L. appendiculata*, 31-2-S12, Franklin Co., Arkansas. ×-1398-S1, greenhouse, May 21, 1957.

×-1450: *L. puberula* f. *puberula*, 108-54-S3, southwest of Hertford, North Carolina, × *L. appendiculata*, 31-2-S12, Franklin Co., Arkansas. ×-1450-S1 and -S2, greenhouse, June 14, 1957 and May 27, 1957.

×-1513: *L. puberula* f. *puberula*, 108-54-S3, southwest of Hertford, North Carolina, × *L. appendiculata*, 31-2-S12, Franklin Co., Arkansas. ×-1513-S1, greenhouse, June 10, 1957.

10. LOBELIA CANBYI Gray × diploid L. NUTTALLII R. & S.

Morphology

Stem rather delicate, 38.5 cm high, purplish-green and puberulent toward the base, green and almost glabrous toward the raceme; cauline leaves linear or linear-lanceolate, up to 5 mm wide and up to 4.5 cm long; flower including hypanthium, 7.8 mm long; pedicels short-pubescent; calyx-lobes with a few glandular teeth and short hairs; hypanthium short-hirsute; base of lower lip of corolla, glabrous; filament-tube 2.5 mm long; anther-tube pale-coloured, 1.5 mm long.

Much seed for the F_1 was harvested from one medium-sized hypanthium. Only a few of the seeds germinated and only one F_1 hybrid plant was grown to maturity. This hybrid has a combination of the parental species characteristics.

Pollen

The anther-tube of one flower (other flowers in bud) of the F_1 hybrid was pale-coloured, underdeveloped and appeared to contain no normal pollen (small grains seen under binocular, too few to make a slide).

Voucher Specimen

×-1523: *L. canbyi*, 30-1-S5, Robeson Co., North Carolina, × diploid *L. nuttallii*, 22-10, Williamsburg, Virginia. ×-1523-S1, greenhouse, Sept. 18, 1957.

11. LOBELIA CANBYI Gray × L. GATTINGERI Gray

Morphology

Stem delicate, 30 cm high, glabrous above, sparsely short-hirsute toward the base; cauline leaves linear or linear-lanceolate, sessile or subsessile, the margins subentire with numerous callose teeth, up to 5 mm wide and up to 3.5 cm long; inflorescence, a terminal raceme with several secondary branches below; flower including hypanthium, 9-10 mm long; pedicels scabrous; calyx-lobes narrow with glandular teeth and a few short hairs; hypanthium almost glabrous; filament-tube 3.0-3.8 mm long; anther-tube dark-coloured, about 2.0 mm long.

Much seed for the F_1 was harvested from one large hypanthium. Only one F_1 hybrid was grown to maturity. This hybrid has a combination of the parental species characteristics.

Pollen

The anther-tubes of the F_1 hybrid were dark-coloured and contained some pollen. The pollen consisted of 90% small, abnormal, thin-walled grains with poorly-developed contents, 7% giant grains or large grains with abnormally deep-staining contents in iodine-potassium iodide solution and 3% normal-appearing grains that may not have been functional.

Voucher Specimen

×-1524: *L. cambyi*, 30-1-S5, Robeson Co., North Carolina, × *L. gattingeri*, 35-1-B, Davidson Co., Tennessee. ×-1524-S1, greenhouse, May 27, 1957.

12. LOBELIA GATTINGERI Gray × L. FEAYANA Gray

Morphology

Stem delicate, about 15-19 cm high, glabrous; cauline leaves subsessile, light-green, up to 1.4 cm wide and up to 3.4 cm long, the margins crenulate; flower including hypanthium, 9-12 mm long; pedicels puberulent; calyx-lobes narrow, entire or with a few glandular teeth (entire in both parental species); base of lower lip of corolla, densely hirsute, and two greenish tubercles at the base of the lower lip; filament-tube 3.0-3.3 mm long; anther-tube dark-coloured, 1.5-1.8 mm long.

Three F_1 seedlings were grown but only one plant matured. The hybrid specimens have an interesting combination of the parental species characteristics.

Chromosome Behavior

At MI in ×-1134-S1, there were 6 II + 2 I per cell in 2 PMC's and 5 II + 4 I per cell in 11 PMC's.

Pollen

The anther-tubes of the ×-1134-S1, an F_1 hybrid, were dark-coloured but the pollen was not abundant. The pollen consisted of 96% small, abnormal, thin-walled grains with poorly-developed contents and 4% large grains with abnormally deep-staining contents in iodine-potassium iodide solution.

Sterility-fertility

×-1134-S1, an F_1 hybrid, was self-pollinated. The pollen was scarce and poorly developed and no seeds were obtained.

Voucher Specimens

×-1134: *L. gattingeri*, 35-1, Davidson Co., Tennessee, × *L. feayana*, 97-54, Volusia Co., Florida. ×-1134-S1, greenhouse, two sheets, May 8 and June 6, 1956.

13. LOBELIA APPENDICULATA A.DC. × L. GATTINGERI Gray

Morphology of the F_1 Hybrids

Stem strong to rather delicate, 45-61 cm high, glabrous or sparsely pubescent; cauline leaves up to 3.3 cm wide and up to 6.4 cm long; inflorescence sometimes with secondary branches below; flower including hypanthium, 10-14 mm long; pedicels puberulent; calyx-lobes scabrous-ciliate or sparsely scabrous, without or with a few glandular teeth, and auricles small, pale- or blue-coloured, sometimes scarious; hypanthium glabrous; filament-tube 3.3-3.5-(3.8) mm long; anther-tube blue-gray, 1.9-2.2 mm long.

Seven F_1 seedlings were grown. Five plants matured and the F_1 hybrids were vigorous.

Chromosome Behavior

In ×-1106-S1, an F_1 hybrid, there were 7 II per cell in 5 PMC's at MI.

Pollen

The anther-tubes of ×-1106-S1, an F_1 hybrid, were blue-gray in colour, well-developed, and contained large amounts of pollen. The pollen was 98% normal.

Sterility-fertility

×-1106-S1, an F_1 hybrid, was self-pollinated and some seed for the F_2 was

collected. ×-1106-S5 was selfed; eight F_2 plants were very weak and one F_2 seedling was somewhat stronger.

Voucher Specimens

×-1106: *L. appendiculata*, 31-2-S5, Franklin Co., Arkansas, × *L. gattingeri*, 35-1, Davidson Co., Tennessee. ×-1106-S1, -S2, -S3 and -S4, greenhouse, May 8 to July 13, 1956.

Bowden (1959) considered that *L. gattingeri* was closely related to *L. appendiculata* but was distinct enough morphologically and geographically that it should be regarded as a species. The above data confirm the close relationship of these taxa. Whether *gattingeri* should be regarded as a distinct species or as a variety of *L. appendiculata* is a difficult decision and the problem needs to be re-examined.

Six Artificial Bispecific Tetraploid Hybrids

1. LOBELIA SIPHILITICA L. VAR. SIPHILITICA × L. PUBERULA MX. SUBSP. PUBERULA VAR. PUBERULA F. PUBERULA
(see also No. 2a under diploid hybrids)

Morphology

The specimens of the tetraploid F_1 hybrids (×-346) are similar to those of the tetraploid F_2 hybrids (×-364-S). The tetraploid F_1 and F_2 hybrids differ from the diploid hybrids described under diploid hybrid No. 2a as follows: cauline leaves obovate to ovate, sometimes broadly lanceolate, up to 4.5-(7.0) cm wide and up to 11.5-(13.0) cm long; flower including hypanthium 26-31 mm long, the lower corolla-lobes often very large; pedicels hirsute, puberulent or scabrous; calyx-lobes hirsute-ciliate toward the apices and on the auricles, with entire margins and conspicuous auricles; hypanthium hirsute or rather sparsely hirsute to nearly glabrous or glabrous; filament-tube 12-15 mm long; anther-tube blue-gray, 3.9-4.5-(4.8) mm long.

Both the F_1 and F_2 tetraploid hybrids were vigorous. Bowden (1961) suggested several reasons for the appearance of both diploids and tetraploids in ×-346 and the most likely cause was that the seedlings were accidentally sprayed with NNOR.

Chromosome Number and Behavior

×-346 was a mixture of diploids and tetraploids. In an F_1 hybrid, ×-346-S1, $2n = 28 + 2$ sup. At diakinesis in ×-346-S1, there were 14 II + 2 sup. (paired or unpaired) per cell in 13 PMC's and 12 II + 1 IV + 2 sup. (paired or unpaired) per cell in 12 PMC's. In two F_2 plants, ×-364-S-S1 and -S3, $2n = 28 + 2$ sup. At MI in ×-364-S-S1, there were 14 II + 2 sup. (paired or unpaired) per cell in 6 PMC's.

Pollen

In a blue-gray anther-tube of a tetraploid F_2 hybrid, ×-364-S-S1, the pollen was 28 to 37% normal.

Sterility-fertility

×-346-S1, a tetraploid F_1 hybrid, was self-pollinated. Three medium-sized hypanthia were harvested and the seed germinated. The F_2 plants (×-364-S) were numerous and grew vigorously. One of the tetraploid F_2 hybrids (×-364-S-S9) was selfed and much good seed (for the F_3) was produced.

Voucher Specimens

×-346: *L. siphilitica* var. *siphilitica*, 1-50-S11, Knoxville, Tennessee, × *L. puberula* f. *puberula*, 6-1-S3, Charleston Co., South Carolina. ×-346-S1, greenhouse, Sept. 24, 1949 and April 27, 1950.

×-364-S: F_2 plants that resulted from the self-pollination of ×-346-S1. ×-364-S-S1 (three sheets) and -S19, arboretum plots, Sept. 26, 1950 to July 11, 1951. ×-364-S-S8 and -S25, greenhouse, May 26, 1950.

2a. LOBELIA GLANDULOSA Walt. × L. ELONGATA Small; and reciprocal

Morphology of the F_1 *Hybrids*

Stem usually coarse, more than 33-54 cm high, glabrous or nearly glabrous with a few short hairs; cauline leaves linear-lanceolate, linear or rarely oblong, up to 0.5-1.5 cm wide and up to 7-10-(15) cm long, the margins subentire, entire or denticulate, with callose teeth; flower including hypanthium, large, (18)-20-32 mm long; base of lower lip of corolla, densely or sparsely hirsute, rarely nearly glabrous; lower lip of corolla, blue, large and showy, 11-18 mm long; calyx-lobes entire or with few or numerous glandular teeth, up to (7)-9-18 mm long; hypanthium glabrous or nearly glabrous; pedicels puberulent, nearly glabrous or glabrous; filament-tube (6)-8-10.5 mm long; anther-tube usually blue-gray, sometimes pale-coloured (with shorter filament-tube), the blue-gray anther-tubes 3.5-4.2(4.5) mm long.

Most of the F_1 seedlings of ×-338 were green and the F_1 hybrids that matured were vigorous with large showy flowers.

The specimens of the two F_2 populations (×-357-S and ×-358-S) were morphologically similar to the F_1 hybrids.

Chromosome Numbers and Behavior

×-338-S2, an F_1 hybrid, was tetraploid, $2n = 28$; and ×-338-S4, -S5, -S6, -S10 and -S17 (five plants) were tetraploid, $2n = 28 + 1$ sup. ×-707-S1 was also tetraploid, $2n = 28$. An F_2 plant, ×-357-S-S1, from the self-pollination of ×-338-S3, was tetraploid, $2n = 28 + 1$ sup.

At diakinesis and MI in an F_1 hybrid, ×-338-S16, there were 14 II + 1 sup. per cell in 6 PMC's; 12 II + 1 IV + 1 sup. per cell in 3 PMC's; 11 II + 1 IV + 2 I + 1 sup. in 1 PMC; 13 II + 2 I + 1 sup. in 1 PMC; 10 II + 1 IV + 4 I + 1 sup. in 1 PMC; 11 II + 1 III + 3 I + 1 sup. in 1 PMC; and 8 II + 3 IV + 1 sup. in 1 PMC.

Pollen

The anther-tubes of an F_1 hybrid, ×-338-S2 (greenhouse specimen), were blue-gray. The pollen was abundant and about 65 to 70% normal. Some of the normal-sized grains had deeply-stained contents. The anther-tubes of another F_1 hybrid, ×-338-S11 (plot specimen) were blue-gray. The pollen was abundant and about 93% normal.

Sterility-fertility

×-338-S3 and ×-338-S6 were each self-pollinated. Some vigorous F_2 plants were grown (×-357-S and ×-358-S).

Voucher Specimens of the F_1 *Hybrids*

×-338: *L. glandulosa*, 8-1-S3, Charleston Co., South Carolina, × *L. elongata*, 3-3-S2, Charleston, South Carolina. ×-338-S1, -S2, -S4, -S9, -S12, -S15 and -S16, greenhouse, May 14 to Aug. 24, 1949. ×-338-S7, -S11, -S14, and -B-S2, arboretum plots, June 9 to Sept. 2, 1949.

×-665: *L. elongata*, 5-5-S21, Charleston, South Carolina, × *L. glandulosa*, 8-2-S32, Charleston Co., South Carolina. A large amount of seed for the F_1 was collected but only one plant grew. No specimen was preserved.

×-707: *L. elongata*, 5-5-S16, Charleston, South Carolina, × *L. glandulosa*, 8-2-S32, Charleston Co., South Carolina. A few tetraploid F_1 hybrids were grown but no specimens were preserved.

Voucher Specimens of the F_2 *Hybrids*

×-357-S: F_2 plants that resulted from self-pollination of ×-338-S3. S-357-S-S5 and -S8, greenhouse, May 26, 1950.

×-358-S: F_2 plants that resulted from self-pollination of ×-338-S6. ×-358-S-S4, -S8 and -S10, greenhouse, May 26, 1950.

2b. LOBELIA ELONGATA Small × F_1 Hybrid (L. GLANDULOSA Walt. × L. ELONGATA Small)

Morphology

The backcross hybrids (×-360) are morphologically similar to the pollen parent, *L. glandulosa* × *L. elongata* (see 2a).

Many seeds for this backcross population were harvested from four large hypanthia and several dozen backcross hybrids were grown to maturity.

Chromosome Number

One backcross hybrid, ×-360-S1, was examined and was tetraploid, $2n = 28 + 1$ sup.

Pollen

The pollen of a blue-gray anther-tube of a backcross hybrid, ×-360-S1, was abundant and 91 to 95% normal.

Voucher Specimens

×-360: *L. elongata*, 3-3-S1-S-S4, Charleston, South Carolina, × artificial F_1 hybrid, ×-338-S6 (*L. glandulosa*, 8-1-S3, Charleston Co., South Carolina, × *L. elongata*, 3-3-S2, Charleston, South Carolina). ×-360-S1, arboretum plots, July 25, 1950. ×-360-S16 and -S23, greenhouse, May 26, 1950.

3. LOBELIA GEORGIANA McVaugh (unreduced gamete) × L. GLANDULOSA Walt.

Morphology

Stem rather delicate, deep green, glabrous; cauline leaves linear-lanceolate, the margins entire or subentire with callose teeth, up to 1.1 cm wide and up to 7 cm long; flower including hypanthium, up to 24 mm long; calyx-lobes with prominent glandular teeth (often purplish teeth); hypanthium glabrous; base of lower lip of corolla, hirsute; filament-tube about 8 mm long; anther-tube pale-coloured, about 4 mm long.

Three medium-sized hypanthia were collected for the F_1 and contained mostly small brown ovules and a few good seeds. The latter germinated but only one seedling was grown to maturity. This F_1 hybrid was slow-growing and the rosette leaves were variegated, green-white-pink, although the leaves of the mature specimen were dark green.

Chromosome Number

×-1199-S1, an F_1 hybrid, was tetraploid, $2n = 28$. Since *L. glandulosa* is a tetraploid species (Bowden, 1960a), it is logical that the diploid *L. georgiana* parent (Bowden, 1960a) must have contributed an unreduced gamete.

Pollen

The anther-tube of the F_1 hybrid was pale-coloured and contained no pollen.

Voucher Specimen

×-1199: *L. georgiana*, 91-54-S2, Elko, Virginia, × *L. glandulosa*, 100-54-S9, Gainesville, Florida. ×-1199-S1, greenhouse, Oct. 8, 1956.

4. LOBELIA ELONGATA Small × tetraploid L. CARDINALIS L., subspecific hybrid

Morphology of the F_1 *Hybrids*

Stem coarse, more than 60 cm high, densely short-pubescent toward the base, sparsely pubescent below the raceme; cauline leaves large, up to 3.5 cm wide and up to 12 cm long, the margins crenulate, serrate or subentire, with callose teeth; flower including hypanthium, large, up to 25-30 mm long; calyx-lobes linear-subulate, usually entire, rarely with a few glandular teeth; hypanthium glabrous or sparsely short-hirsute toward the base; pedicels densely short-hirsute; corolla deep rose-red in colour; filament-tube 11-15 mm long; anther-tube mostly blue-gray and well developed, rarely pale-coloured and underdeveloped, the blue-gray anther-tubes 3.8-4.3 mm long.

Only a few seeds for the F_1 were collected and only two F_1 hybrids matured.

The F_2 specimen (×-802-S-S1) was similar to the F_1 hybrids but had much larger, leafy flower-bracts and longer filament-tubes, 18-19 mm long.

Chromosome Behavior

In ×-606-S1, an F_1 hybrid, $2n = 28 + 1$ sup. At diakinesis and MI in ×-606-S1, there were 14 II + 1 sup. per cell in 15 PMC's; 13 II + 2 I + 1 sup. per cell in 3 cells; 11 II + 1 IV + 2 I + 1 sup. in 1 PMC; and 12 II + 4 I + 1 sup. in 1 cell. This slide was not as good as most other slides of meiotic material of *Lobelia*.

At diakinesis and MI in an F_2 plant, ×-802-S-S13, there were 14 II per cell in 15 PMC's; 13 II + 2 I per cell in 4 PMC's; and 12 II + 1 IV in 1 PMC.

Pollen

A blue-gray anther-tube of ×-606-S1, an F_1 hybrid, contained much pollen. The pollen was 94% normal.

Sterility-fertility

×-606-S1, an F_1 hybrid, was self-pollinated and many F_2 plants were grown.

Voucher Specimens

×-606: *L. elongata*, 5-5-S2, Charleston, South Carolina, × ×-363-S-S5, tetraploid ($2n = 28 + 2$ sup.) *L. cardinalis* L., subspecific hybrid involving *L. cardinalis* var. *cardinalis* and *L. cardinalis* subsp. *graminea* cv. 'Illumination'. ×-606-S1, arboretum plots, Sept., 1951 and greenhouse, two sheets, Feb. 11 and Sept. 12, 1952.

×-802-S: F_2 plants that resulted from self-pollination of ×-606-S1. ×-802-S-S1, arboretum plots, Aug. 29, 1952.

5. LOBELIA AMOENA MX. × L. ELONGATA Small; and reciprocal

Morphology of the F_1 *Hybrids*

Stem coarse, up to more than 90 cm high, sparsely short-pubescent or nearly glabrous, often purplish toward the base; cauline leaves broadly-lanceolate or lanceolate, up to 2-3.5 cm wide and up to 9-12-(14) cm long, the margins subentire, almost entire or crenulate, with callose teeth; flower-bracts short, 0.5-1.0 cm long, or long, up to 3-4-(7) cm long, sometimes leafy; flower including hypanthium, 16-25 mm long; calyx-lobes narrow, greenish or purplish, margins entire or rarely with a few glandular teeth, (5)-9-13-(17)

mm long, (specimens of *L. elongata* × *L. amoena* tend to have longer calyx-lobes than the reciprocal hybrids); hypanthium glabrous or short-hirsute toward the base; pedicels puberulent, short-puberulent or nearly glabrous; filament-tube (6-7)-8-9 mm long; anther-tube, usually blue-gray and well-developed, or pale-coloured and underdeveloped (in such flowers the filament-tube is shorter), the blue-gray anther-tubes, 3.0-4.5 mm long.

Many vigorous plants of four different F_1 populations were grown to maturity.

Chromosome Behavior

Meiosis was studied in three different F_1 hybrids. Diakinesis in ×-767-S4 showed 14 II per cell in 18 PMC's and 12 II + 1 IV per cell in 2 PMC's. At MI and diakinesis in ×-765-S5, there were 14 II per cell in 24 PMC's and 12 II + 1 IV in 1 PMC. At diakinesis in ×-860-S1, there were 14 II per cell in 9 PMC's and 12 II + 1 IV in 1 PMC.

Pollen

The anther-tubes of ×-767-S11, an F_1 hybrid, were blue-gray and the hypanthia (OFP) set seed. The pollen was abundant and 97% normal.

Sterility-fertility

×-767-S2, an F_1 hybrid, was self-pollinated, much seed was obtained and a few vigorous F_2 plants (×-890-S) were grown to maturity.

Voucher Specimens

X-767: *L. amoena*, 3-5-2-S2, Clarke Co., Georgia, × *L. elongata*, interstrain hybrid, ×-495-S12. ×-767-S5, -S6, -S8, -S10, -S11 and -S12, arboretum plots, Aug. 20 to Oct. 1, 1952.

×-890-S: F_2 plants that resulted from self-pollination of ×-767-S2. ×-890-S-S1, arboretum plots, Sept. 1953. This F_2 specimen resembled the *L. elongata* parent.

×-765: *L. elongata*, 3-3-S1-S-S1-S-S13, Charleston, South Carolina, × *L. amoena*, 3-5-3-S4, Clarke Co., Georgia. ×-765-S2, -S3, -S6, -S7, -S11 and -S12, arboretum plots, eight sheets, July 28 to Oct. 1, 1952.

×-766: *L. elongata*, 5-5-S19, Charleston, South Carolina, × *L. amoena*, 3-5-3-S3, Clarke Co., Georgia. ×-766-S1, -S4, -S6, -S9 and -S16, arboretum plots, July 28 to Oct. 1, 1952.

×-860: *L. elongata*, ×-763-S3, interstrain hybrid, × *L. amoena*, 3-5-3-S25, Clarke Co., Georgia. ×-860-S1, -S3, -S7, -S9 and -S11, arboretum plots, Aug. 27 to Oct. 1, 1952.

6. LOBELIA AMOENA MX. × L. GLANDULOSA Walt.; and reciprocal

Morphology of the F_1 Hybrids

Stem usually coarse, 49-100 cm high, glabrous or nearly glabrous or sparsely short-hirsute toward the base; cauline leaves usually long linear-lanceolate, sometimes lanceolate, up to 1.2-2.2 cm wide and up to 11-18.5 cm long, the margins entire or subentire with callose teeth; flower including hypanthium, large, 22-30-(31.5) mm long; base of lower lip of corolla, hirsute; lower lip of the corolla, blue, large, 10-15 mm long; calyx-lobes entire or with few or rather numerous glandular teeth, up to 1.0-2.0 mm wide and up to 7-14 mm long; hypanthium densely to sparsely long-hirsute or nearly glabrous; pedicels puberulent, short-hirsute, densely hirsute or nearly glabrous; filament-tube (7.0)-8.0-9.5 mm long; anther-tube usually blue-gray, sometimes pale-coloured, the blue-gray anther-tubes (2.8)-3.0-3.5 mm long.

Five different F_1 populations were grown. Many seedlings were small but numerous vigorous F_1 plants were grown to maturity.

The F_2 specimen, ×-1443-S-S5, resembled the specimens of the F_1 hybrids.

Chromosome Behavior

In ×-1195-S4, an F_1 hybrid, there were 14 II per cell in 10 PMC's at diakinesis and MI.

Pollen

The anther-tubes of ×-1195-S4, an F_1 hybrid, were blue-gray. The pollen was abundant and 80% normal.

Sterility-fertility

×-1200-S2, an F_1 hybrid, was self-pollinated. Three large hypanthia were harvested and they contained much good seed. Many of the seeds germinated and five F_2 plants (×-1443-S) were grown to maturity.

Voucher Specimens

×-1194: *L. amoena*, 3-5-S-S16-OFP-S3, Clarke Co., Georgia, × *L. glandulosa*, 100-54-S11, Gainesville, Florida. ×-1194-S1, -S2, -S3 and -S4, greenhouse, July 13 to Aug. 8, 1956.

×-1195: *L. amoena*, 3-5-S-S16-OFP-S5, Clarke Co., Georgia, × *L. glandulosa*, 100-54-S11, Gainesville, Florida. ×-1195-S1, -S2, -S3, -S4 and -S6, greenhouse, July 13 to Aug. 14, 1956.

×-1276: *L. amoena*, 3-5-S-S16-OFP-S3, Clarke Co., Georgia, × *L. glandulosa*, 100-54-S12, Gainesville, Florida. ×-1276-S1, greenhouse, Aug. 14, 1956.

×-1219: *L. glandulosa*, 100-54-9B, Gainesville, Florida, × *L. amoena*, 3-5-S-S16-OFP-S1, Clarke Co., Georgia. ×-1219-S1, -S2 and -S3, greenhouse, Aug. 8, 1956.

×-1200: *L. glandulosa*, 100-54-S5, Gainesville, Florida, × *L. amoena*, 3-5-S-S16-OFP-S12, Clarke Co., Georgia. ×-1200-S3, -S4, -S5, -S7 and -S10, greenhouse, July 13 to Aug. 14, 1956.

×-1443-S: F_2 plants that resulted from self-pollination of ×-1200-S2. ×-1443-S-S5, greenhouse, June 10, 1957.

An Artificial Bispecific Hexaploid Hybrid

LOBELIA PALUDOSA Nutt. × L. FLORIDANA Chapman

Morphology

Stem 48-87 cm high; basal leaves thick, oblanceolate, 3-20 mm wide, 5-21 cm long; flower including hypanthium, 17-21 mm long; corolla-tube fenestrate (fenestration small) in ×-1288-S6 and not fenestrate in ×-1288-S2; each pedicel with a pair of small bracteoles near the base; filament-tube, 6.0-7.5 mm long. The F_1 hybrids of ×-1288 were slow-growing but the mature plants were vigorous. The F_1 hybrids have a combination of characteristics of both parents with a strong tendency toward the pollen parent, *L. floridana*.

Chromosome Number

Bowden (1960a) reported that both parents of this hybrid were hexaploid, $2n = 42$. Chromosome number was not determined on the F_1 hybrids but the plants had the morphological characteristics of hexaploids.

Pollen

The pollen of one of the F_1 hybrids, ×-1288-S2, was examined; it was

abundant and about 80% normal. The anther-tubes of both ×-1288-S2 and -S6 were well developed and blue-gray in colour. The pollen of selected plants of the parental species strains was 97% normal.

Voucher Specimens

×-1288: *L. paludosa*, 24-1-A-S5, St. Petersburg, Florida, × *L. floridana*, 104-54-S6, near Springfield, Florida. ×-1288-S2, greenhouse, May 8, 1957. ×-1288-S6, greenhouse, April 29, 1957.

×-1143: *L. paludosa*, 24-1-A-S2, St. Petersburg, Florida, × *L. floridana*, 104-54-S4, near Springfield, Florida. The F_1 hybrids of ×-1143 were weak, slow-growing, and some of the small plants died in the rosette stage. No specimens of ×-1143 were preserved.

Summary

Cytotaxonomic data are presented for 13 artificial bispecific diploid *Lobelia* hybrids: *L. puberula* × *L. georgiana*; *L. siphilitica* × *L. puberula*; *L. siphilitica* × *L. georgiana*; *L. siphilitica* × *L. brevifolia*; *L. georgiana* × *L. brevifolia*; *L. puberula* × *L. feayana*; *L. flaccidifolia* × *L. puberula*; *L. flaccidifolia* × *L. feayana*; *L. puberula* × *L. appendiculata*; *L. canbyi* × diploid *L. nuttallii*; *L. canbyi* × *L. gattingeri*; *L. gattingeri* × *L. feayana*; and *L. appendiculata* × *L. gattingeri*. Six artificial bispecific tetraploid hybrids are reported: *L. siphilitica* × *L. puberula*; *L. glandulosa* × *L. elongata*; *L. georgiana* (unreduced gamete) × *L. glandulosa*; *L. elongata* × tetraploid *L. cardinalis*; *L. amoena* × *L. elongata*; and *L. amoena* × *L. glandulosa*. *Lobelia paludosa* × *L. floridana* is an artificial bispecific hexaploid hybrid.

These 19 bispecific *Lobelia* hybrids have various combinations of the parental species characteristics. Although some characteristics of the hybrids are practically intermediate or more or less intermediate between the parental species, most hybrids have some characteristics inherited from one parent and other characteristics from the other parent. Some of the hybrids tend to resemble one parent more strongly than the other. Many of the hybrids had meiotic irregularities and various percentages of abnormal pollen. The tetraploid hybrids were generally more fertile and produced more vigorous F_2 plants than the diploid hybrids.

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